Fermilab

EXP. 75

February 4, 1976

ACCELERATOR EXPERIMENT: Beta Bump In The Booster

EXPERIMENTER LIST: Booster Group

Date Performed: January 18, 1976

A vertical "beta bump" was tried in the Booster in an attempt to reduce the beam loss that occurs on the extraction septum. This goal was accomplished but with increased beam loss in other parts of the ring.

Objective

Because the extraction septum in the Booster must hang down into the aperture it is a vertical aperture limit. The question then arises: can the vertical beam size be reduced in the extraction period of the Booster. Beam size is determined by the machine beta and the beam emittance. A localized variation in beta is called a "beta bump". Producing a localized beta variation in the booster within existing machine constraints involves some difficulties. S. Ohnuma has proposed a nonlocal scheme that introduces a super periodicity into the booster lattice. His scheme uses existing trim quadrupoles and reduces the vertical beta at the extraction septum. The present experiment was to measure the changes in beta and in the beam loss pattern that resulted from such a beta modification.

Bump Scheme

S. Ohnuma's plan is to put in harmonics in the trim quadrupoles that should produce the desired super-period structure in the beta function. His suggested ratios are:

Quad Short 1, 5, 9, 13, 17, 21	-.6
Quad Short all others	.0
Quad Long even numbers	-1.0
Quad Long odd numbers	+1.0

If the initial tunes of the booster are 6.7 horizontally and 6.8 vertically, then the prediction for the above bump at full strength is that long straight section vertical betas should increase (20 to 26m) in even periods and decrease (20 to 16m) in odd periods. The tunes should change to 6.777 horizontally and 6.732 vertically.

Experiment

To start the experiment all trim quadrupoles were turned off. Slight adjustments in the average values were made to have the tunes at 6.7 horizontally and 6.8 vertically. Vertical tune shifts were measured as a function of the trim quadrupole strength at Long 11, 12, 13, 14, 15 and 16. The betas are given by:

$$\text{Beta} = \Delta\nu \text{ (for a 2 Amp change) } *630\text{m}$$

Figure 1 shows the beam loss monitors in Long 13 to 24 in the initial condition. Figure 2 shows the same monitors with the quadrupoles in the proper ratios at 2/3 maximum strength. Notice that the loss at L13 was almost completely eliminated. Increased loss at L18 was observed. Beam intensity and transmission also went down. The tune shift was such as to cause coupling between the horizontal and vertical tunes making their measurement unreliable.

At full strength, lower beam transmission was observed, but the tune measurements were more reliable. Table I shows the 8GeV charge, Booster transmission, tunes, and measured betas for no beta bump and maximum strength beta bump. Even period beta's went up. Odd period beta's went down. Tunes had a remarkable agreement with the predicted values. Beam loss at Long 13 was virtually eliminated. However the phototubes showed increased losses at other places (Long 11 and 18 for example). Tuning trim dipoles allowed reduction in the loss at Long 2, 11, 18 and Short 18. This seemed to occur at the expense of increased losses at Short 1, 14, 21, 22, and 24. Attempts to retune and gain back most of the beam intensity lost by putting in the beta variation failed.

Figures 3-6 show the loss monitors with the large beta variation. Loss at Long 13 is very minimal. Restoring the Booster to the nominal operating parameters produced an increase in beam to 1.39×10^{12} with a transmission of 54%. Figures 7-10 show the loss monitors for the nominal operating condition. Scattered losses seem to be traded for solid losses at Long 2 and 13. The structure of the loss at Short 1 changed.

Conclusion

In spite of the lowered beam intensity, the experiment was successful. S. Ohnuma was able to calculate and predict a change in the tunes, the vertical betas and the beam loss at Long 13. This experiment is further evidence that the beam size is too large for the available aperture at the extraction septum. At the same time, beta changes at other places in the booster resulted in immediate beam loss. It seems possible that a beta bump of a smaller size and/or a more localized bump might actually enable reduced loss at the septum with increased beam intensity.

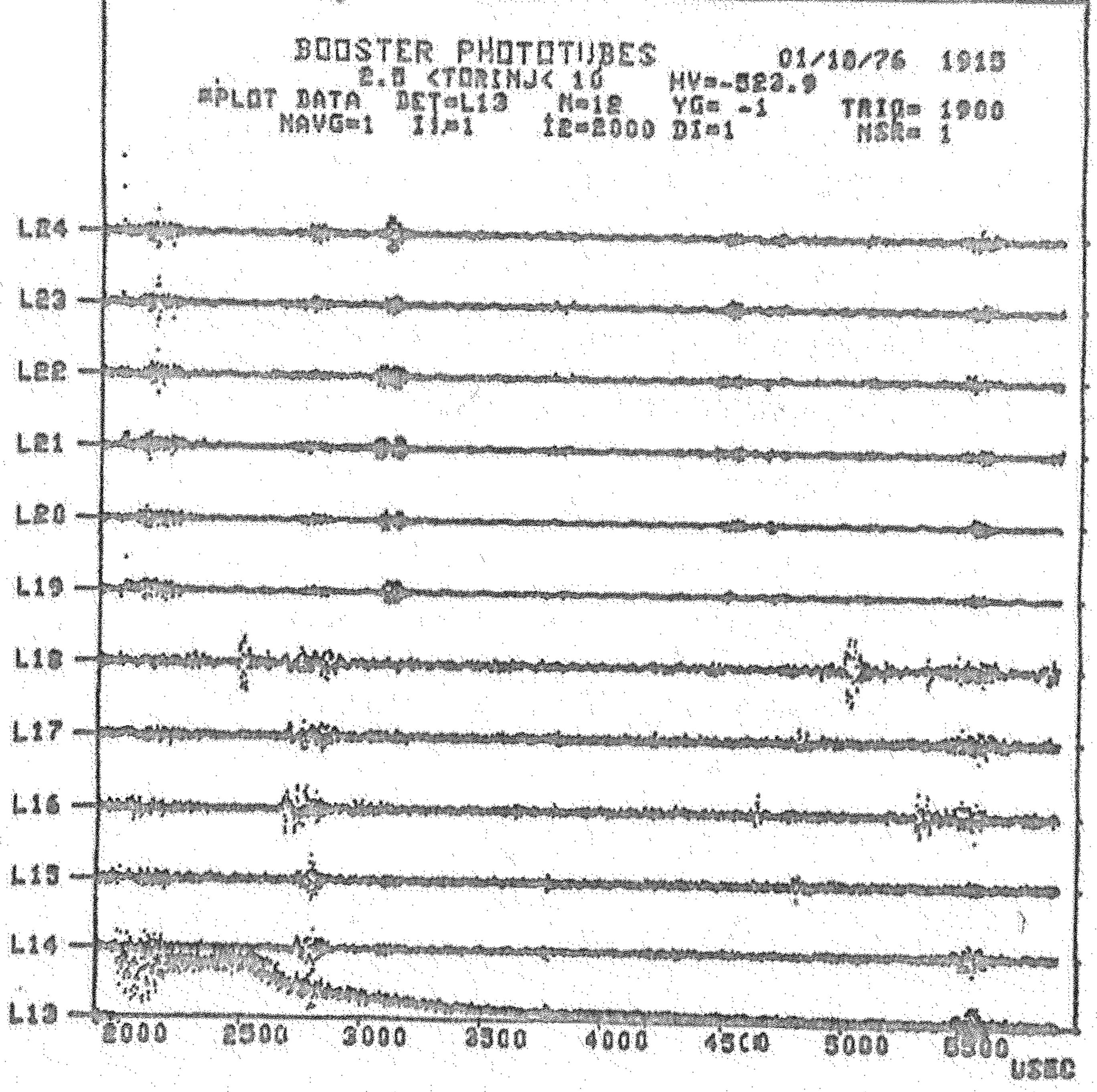
E. Gray

TABLE I

	No Beta Bump	Max Beta Bump
Linac Current	140 mA	140 mA
Booster Transmission	49%	34%
8 GeV Charge	1.26×10^{12}	$.87 \times 10^{12}$
Tune Hor	6.7	6.78
Tune Ver	6.8	6.72
Ver Beta L11	18.9	13.2
Ver Beta L12	20.5	34.3
Ver Beta L13	19.8	13.9
Ver Beta L14	19.8	33.4
Ver Beta L15	17.6	12.0
Ver Beta L16	20.2	33.1

Start

Figure 1 Initial Beam Loss



Bump -4

Figure 2 2/3 Beta Bump

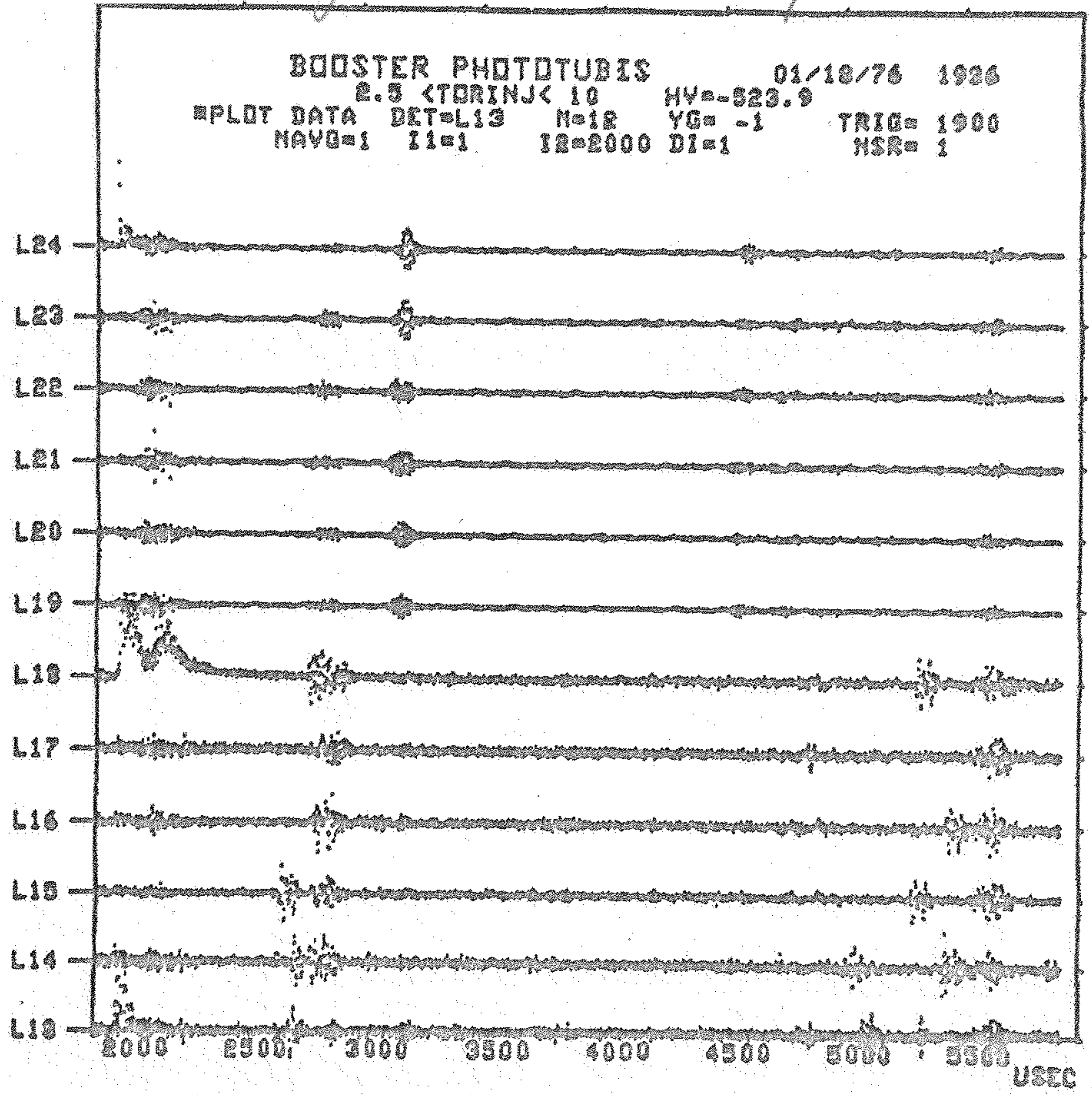


Figure 3 Large beta bump

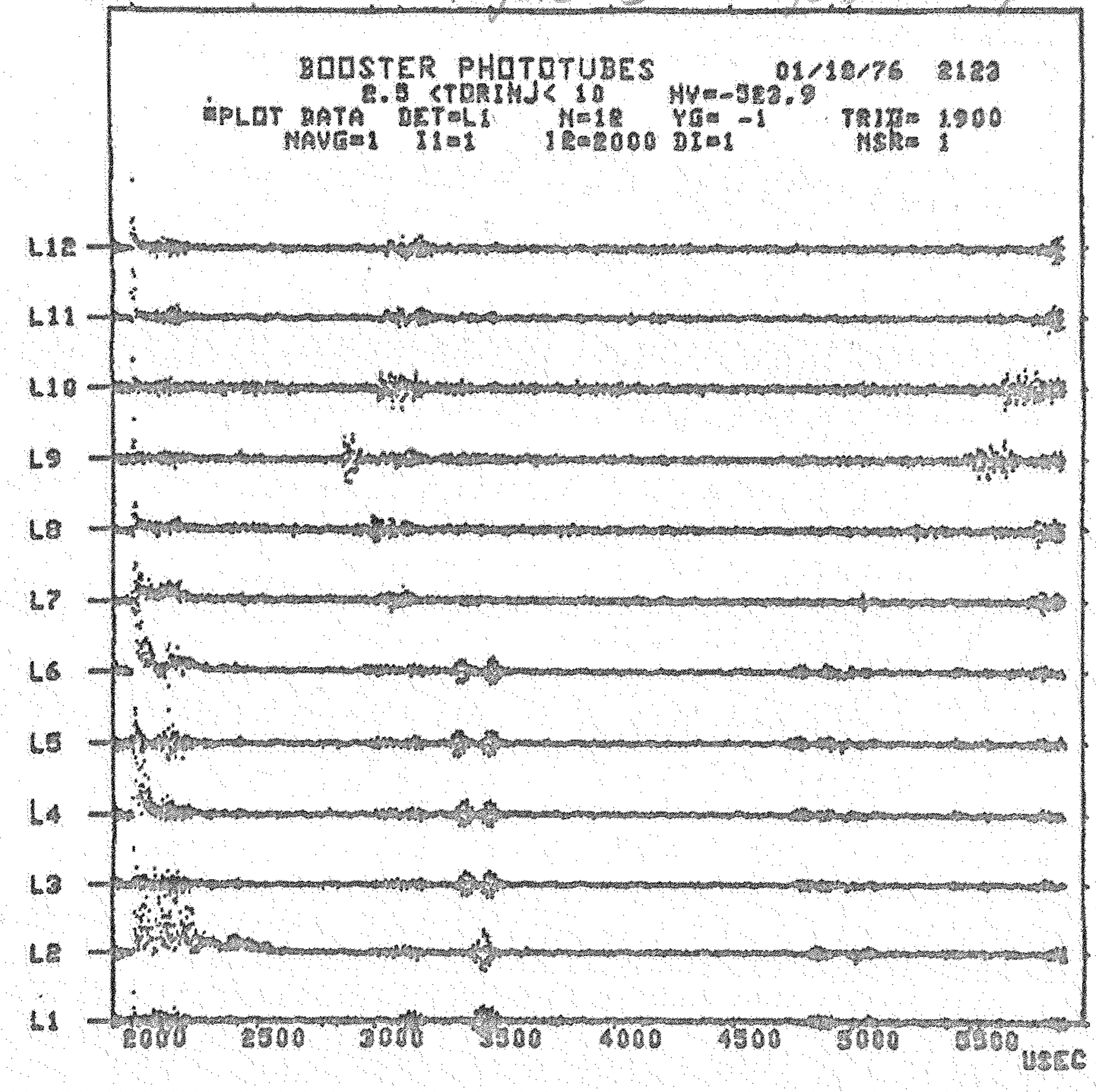


Figure 4 Large Beta Bump

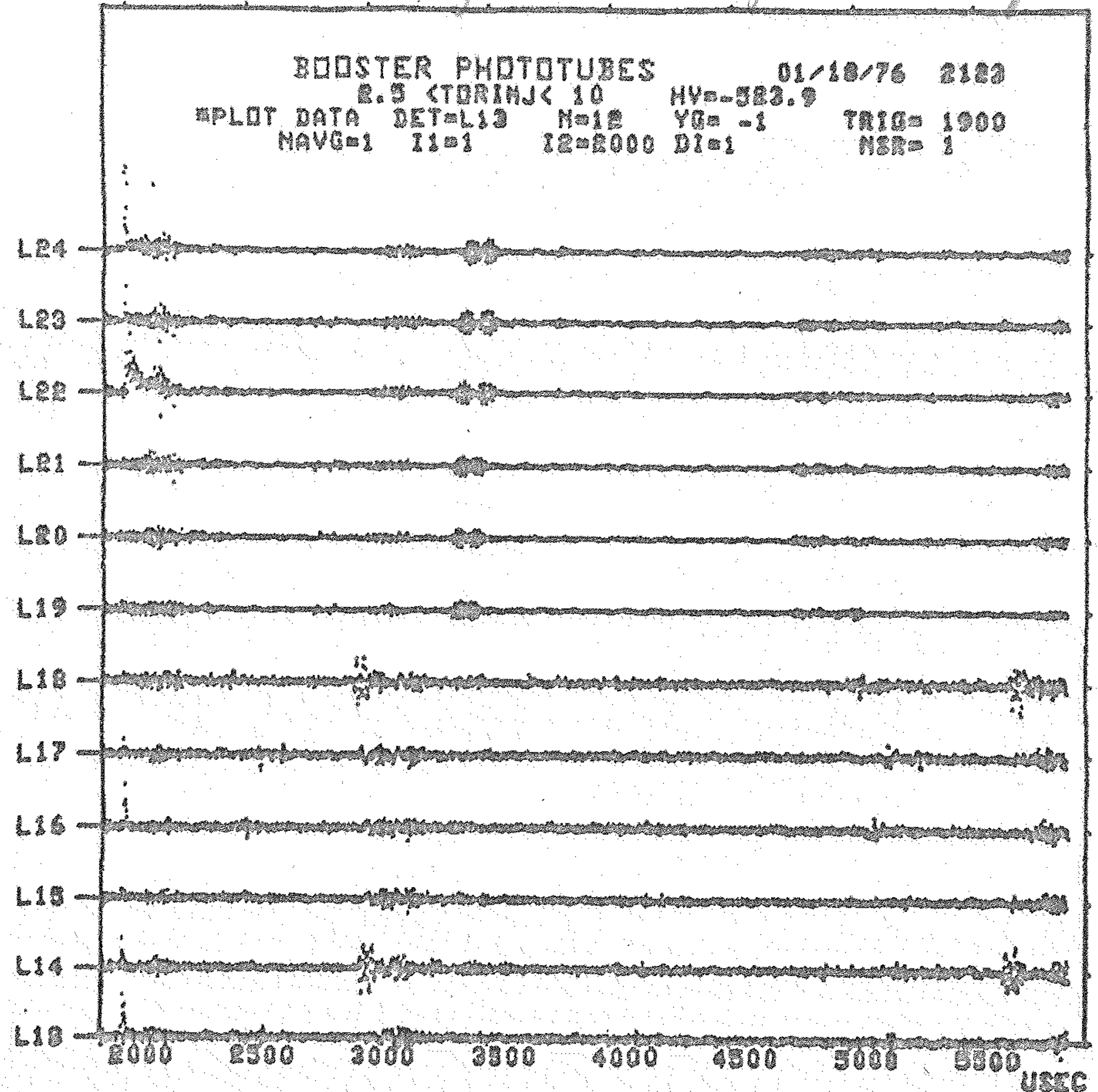
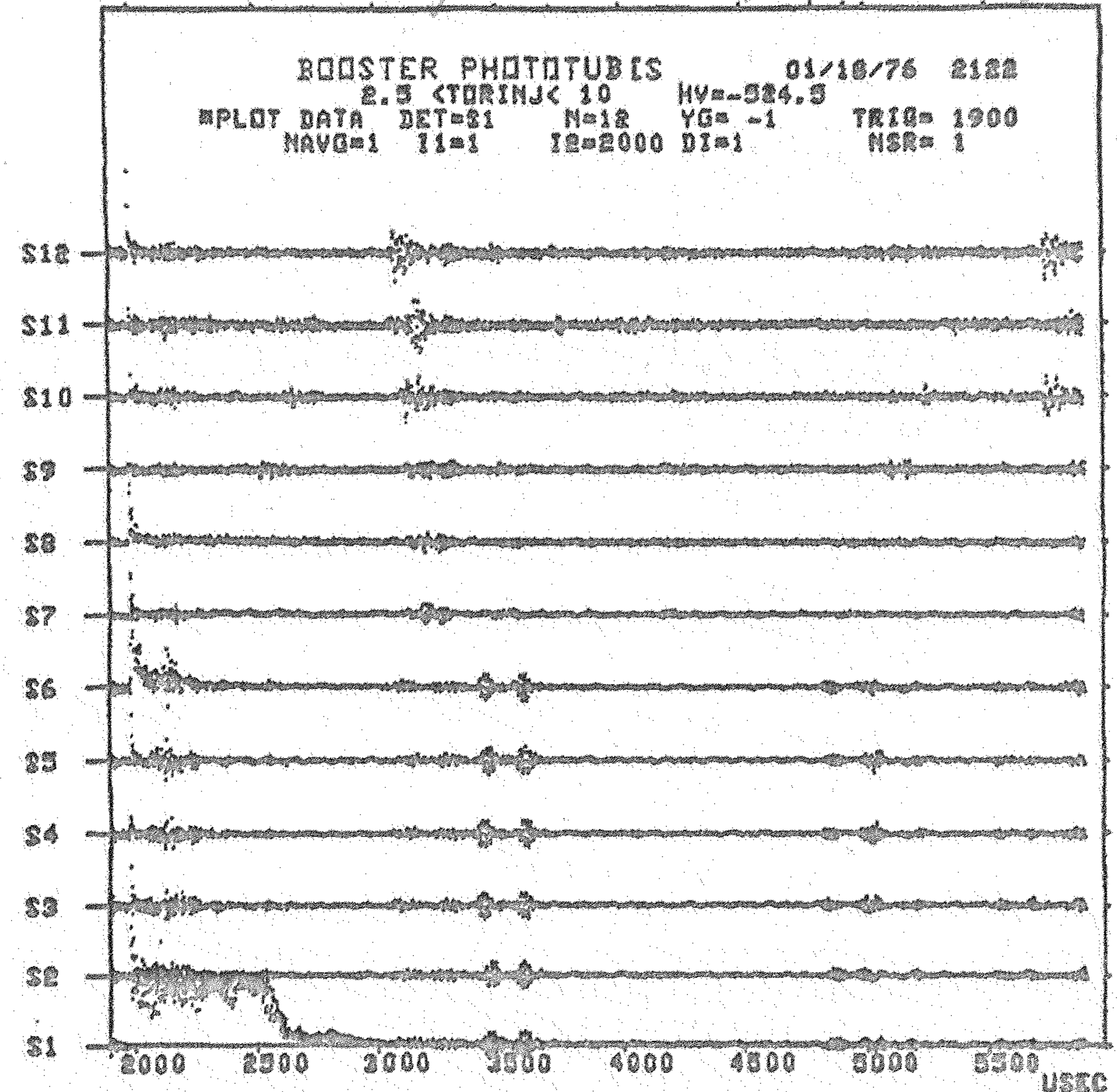


Figure 5 Large Beta Bump



Bump = 6 3

H.78 V.72

Figure 6 Large Beta Bump

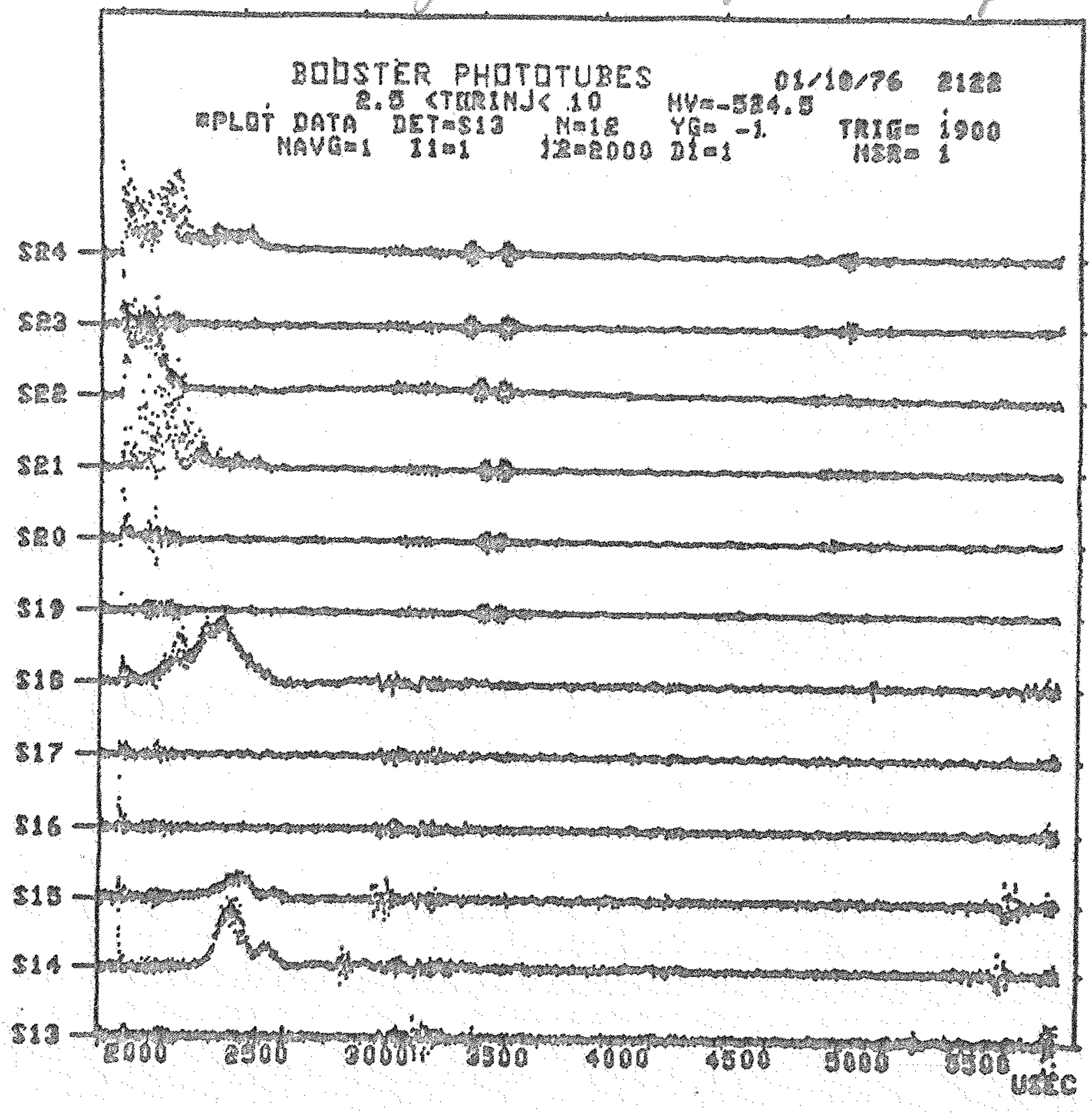
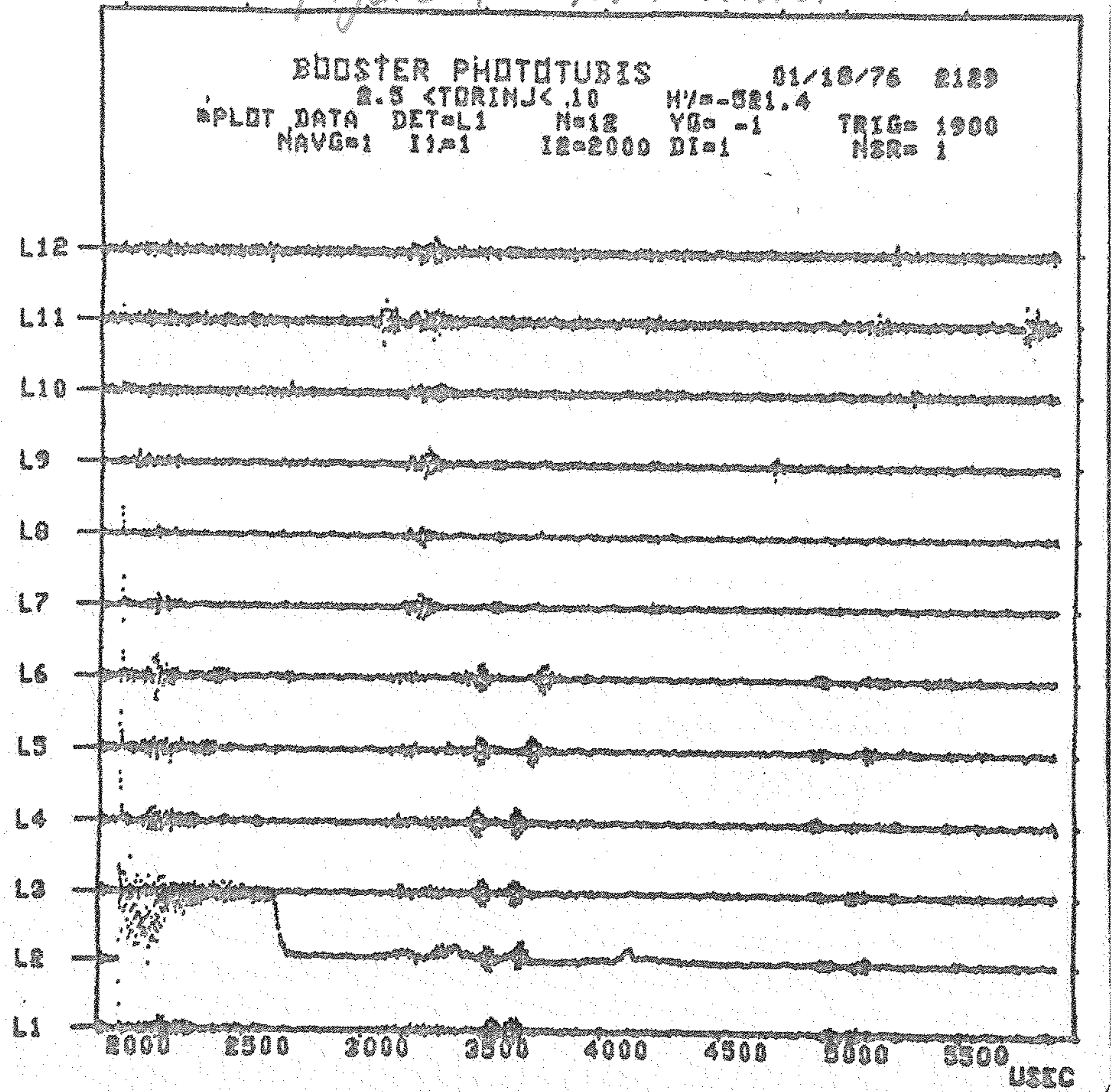


Figure 7 Nom Booster



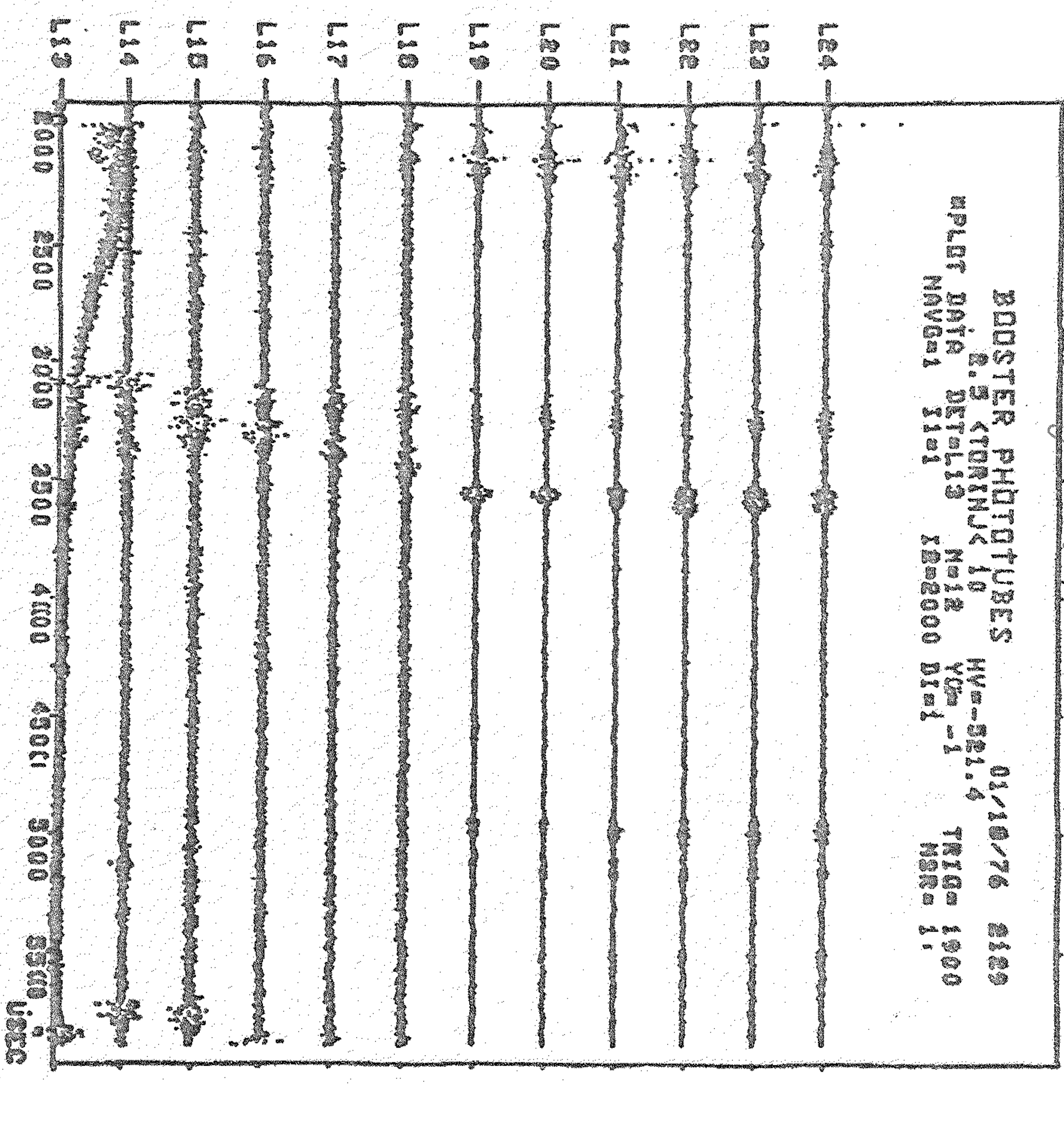


Figure 8 Nom booster

Restore

Figure 9 Nom Booster

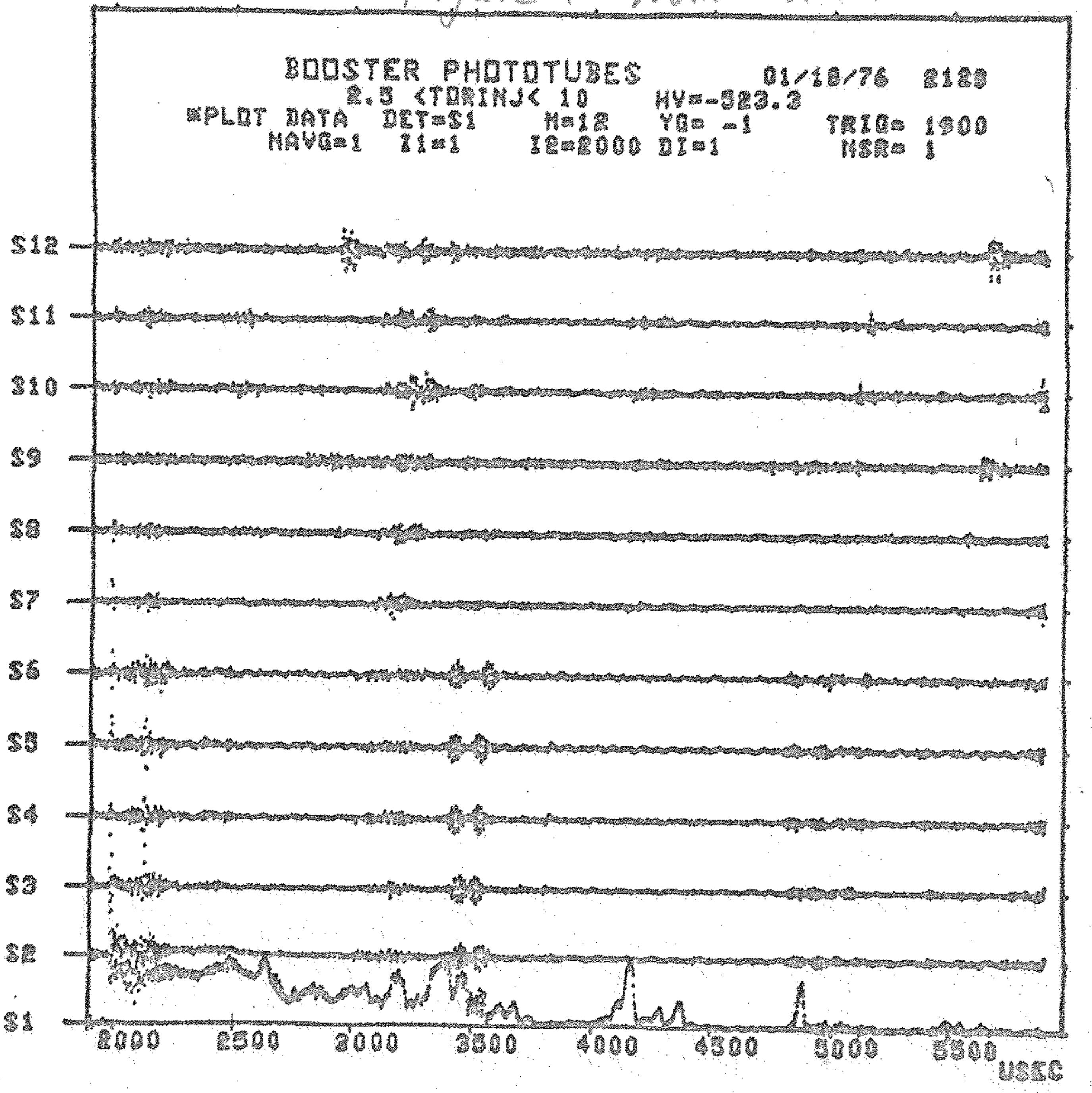


Figure 10 Nim Booster